HIGHLY EFFICIENT FIELD EMITTER USING CARBON NANOTUBES GROWN BY MICROWAVE PLASMA ENAHNCED CVD

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ABSTRACT

Since the discovery of carbon nanotubes (CNTs) in 1991, studies on their characteristics and potential applications in various fields have been overwhelming. Due to their small tip radius of curvature, CNTs are ideal candidate for field emission.

In this paper, the experiment on field emission by carbon nanotubes with extremely low turn-on electric field of about 0.3 V/μm is reported. The CNTs tested for field emission were grown on n-type silicon wafer by microwave plasma enhanced chemical vapor deposition (MPECVD). A thin film of transition metal palladium (Pd), acting as a catalytic center for nanocluster nucleation was sputtered on the silicon substrate with a patterned mask. The substrate was then transferred to the CVD machine for carbon deposition. The deposition was carried out under working pressure of 10 Torr, temperature of 700 ^{o}C and microwave power of 400 watts. The flow ratio of the gas mixtures of methane (CH_4) and hydrogen (H_2) was 5:1. The growth time of the CNTs was set at 10 minutes.

Under scanning electron microscopy (SEM) inspection (Figure 1), the CNTs obtained were highly dense and having diameter ranged from 40 to 60 nm. Generally, the alignment of the CNTs was curly in shape and “Spagetti-like”.

Field emission current was measured at room temperature in a vacuum chamber at 10^{-6} Torr. The distance between the anode and CNTs was kept at 50μm with spacers. The current density vs. electric field plot (Figure 2) showed that an extremely low turn-on field of approximately 0.3 V/μm was obtained. An emission current density of 0.8 mA/cm^2 was achieved at approximately 0.5 V/μm. From the Fowler-Nordheim (F-N) plot (Figure 3) of the same data confirmed that the current observed was indeed emission current.

The results obtained demonstrated that carbon nanotubes produced by MPECVD method in this experiment is a very good field emitter with extremely low turn-on field and high current density.

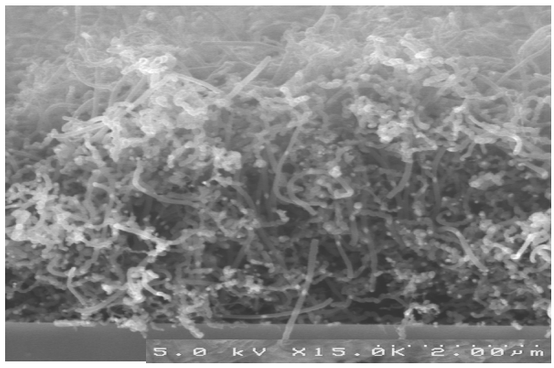

Figure 1: SEM micrograph of the carbon nanotubes.

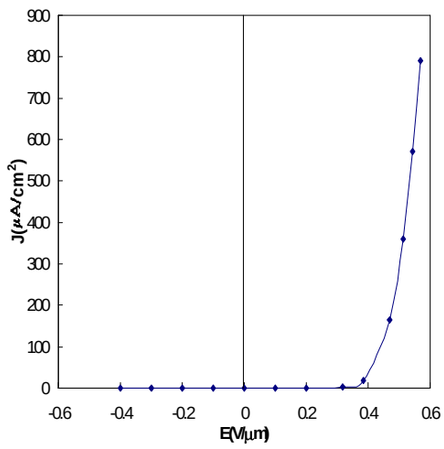

Figure 2: Measured emission current density vs. electric field plot of carbon nanotubes field emitter.

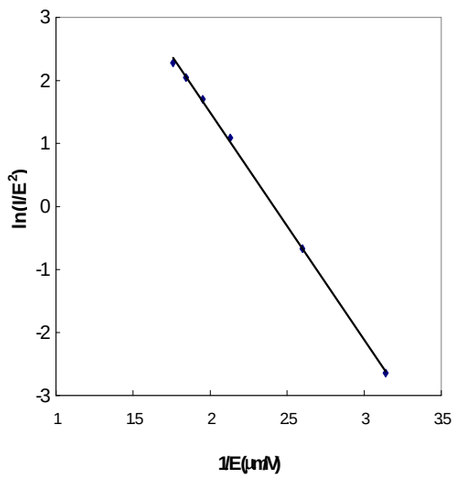

Figure 3: Fowler-Nordheim (F-N) plot of carbon nanotubes field emitter.